FLUOR DANIEL

ATTACHMENT 3

SUMMARY REPORT ON SAMPLING STUDY TO EVALUATE THE EFFECT OF TORSIONAL MOMENT ON PIPE STRESS QUALIFICATION.

PRAIRIE ISLAND AND KEWAUNEE NUCLEAR POWER PLANTS

Project No. 834486
Report No. R.834486-1
Date: March 3, 1989

Prepared By: R. N. Patel
Reviewed By: B. L. Dickerson
J. K. Kaliyadan
Approved By: A. Casillo

8903160281 890310
PDR ADOCK 05000305
Q PDC

FLUOR DANIEL

Report No. R.834486-1
Project No. 834486

TABLE OF CONTENTS

1.0 INTRODUCTION/SUMMARY

2.0 EVALUATION

2.1 SELECTION OF SAMPLES

2.2 SCREENING OF SAMPLES

2.3 ANALYSIS OF RELEVANT SAMPLES

3.0 RESULT

4.0 CONCLUSION

5.0 REFERENCES

1.0 INTRODUCTION/SUMMARY

During the recent NRC audit, the question was raised regarding the interpretation of the term "longitudinal stress" in USAS B31.1.0-1967 Power Piping Code, which is the licensing basis for Prairie Island and Kewaunee Nuclear Generating Plants (References 2 and 7). The question was raised: "Does the Fluor Daniel interpretation of using two bending moments in pipe stress calculation for Upset and Faulted loading combinations adequately meet the intent of the code?" In response to this question, in addition to the technical justification provided in Reference 6, this study is performed to determine the effect of the torsional moment and show that the piping systems are within the limits of the USAR criteria.

The results of this study shows that it is not necessary to include the torsional moment in the stress calculation and that the interpretation of the term "longitudinal stress" is correct. The inclusion of torsional moment is considered outside the design basis for these plants.

This study is based on the statistical method of selecting samples and analyzing them. The evaluation is performed in accordance with the procedure contained in Reference 4. According to the procedure, the size of the randomly selected sample should be 58 to achieve a 95% confidence level that the total population conforms to the results and conclusions.

Section 2.1 describes the random selection of samples. These samples are screened in regard to the minimum stress levels defined in the procedure to determine the relevant samples. There are a total of 13 analytical parts found as relevant as discussed in section 2.2. These relevant analytical parts are analyzed for pipe stress qualification, including the effect of torsional moment. The result show that all of the 13 relevant samples meet the USAR criteria.

2.0 EVALUATION

There are a total 1,428 safety-related piping analytical parts existing for Prairie Island and Kewaunee Projects combined. A sampling study, based on a random selection method, is adopted for this study. The following subsections describe and document the evaluation performed.

2.1 SELECTION OF SAMPLES

To randomly select the required samples of analytical parts, a PC program written in BASIC with the Random Generator function is used. Each of the 1,428 analytical parts is assigned a unique record number from 1 to 1,428. Reference 5 of this report contains the documentation of the random selection process and the list of all analytical parts. The 58 randomly selected analytical parts, which are used in this study, are listed in Table 2.2. This sample size achieves a 95% confidence level and is consistent with the sample size requirement of IE Bulletin 79-02.

2.2 SCREENING OF SAMPLES

The objective of screening the samples is to eliminate those analytical parts having a stress level too low to cause an overstress when the torsional moment is included in the pipe stress calculation. The screening criteria, as discussed in Reference 4, is as follows:

TABLE 2.2
SUMMARY OF EXISTING STRESS LEVELS FOR 58 SAMPLES

RECORD NO.	REPORT NO.	PART NO.	SYSTEM ID	INDEX NO.	PIPE SIZE♦	MAX STRESS RATIO UPSET	MAX STRESS RATIO FAULTED	STRESSES** OBE♦♦	STRESSES** 1/2 Sh
662	PI-233-50	16	CL	126	S	0.3288	0.2598	1124	7500
* 442	PI-216-3	3	RH	010	S	0.4712	0.5404	5309	6500
737	PI-233-27	33B	CC	547	L/S	0.3330	0.4370	8253	7500
* 424	PI-213-9	2CA-2	CS	018	S	0.4520	0.5840	7641	7500
992	PI-233-44	47B	CC	653	S	0.1275	0.1000	863	7500
308	PI-211-14	10F	WG	037	S	0.0630	0.0052	540	7500
996	PI-223-34	7B	CC	657	L/S	0.1440	0.1660	1889	7500
* 792	PI-234-19	3B	RC	039	S	0.8135	0.6240	3671	5550
[illegible]	PI-211-22	8A-1	WG	134	S	0.1380	0.0967	176	7500
670	PI-233-51	25	CL	134	L/S	0.2457	0.2480	2291	7500
* 18	PI-205-IV	48	SI	011	L	0.7033	0.7567	6748	6500
323	PI-211-15	11NB	WG	052	S	0.0687	0.0540	220	7500
929	PI-326-I	D	FO	034	L	0.1420	0.1060	246	7500
170	PI-206-40	35A	VC	557	S	0.3413	0.2771	2367	6683
967	PI-233-38	28A	CC	628	S	0.1400	0.1770	2281	7500
788	PI-234-18	2F	RC	035	S	0.2600	0.3230	4609	8138
734	PI-233-27	32A(UPPER)	CC	544	L/S	0.4660	0.4070	2674	7500
953	PI-233-37	15B	CC	614	S	0.1111	0.1053	1290	7500
* 440	PI-216-3	1	RH	008	S	0.5560	0.6750	7148	7500
247	PI-206-59	39B	VC	634	S	0.0217	0.0208	293	9375
* 581	PI-233-XV	VI	CL	012	L	0.6210	0.7490	9062	7500
* [illegible]	PI-216-V	9A AND B	RH	014	L	0.6600	0.7307	8306	7625
650	PI-233-12	1	CL	114	L/S	0.1230	0.0986	690	7500
959	PI-233-38	19A	CC	620	S	0.1794	0.2344	2266	750

TABLE 2.2 (Continued)
SUMMARY OF EXISTING STRESS LEVELS FOR 58 SAMPLES

RECORD NO.	REPORT NO.	PART NO.	SYSTEM ID	INDEX NO.	PIPE SIZE♦	MAX STRESS RATIO UPSET	MAX STRESS RATIO FAULTED	STRESSES** OBE♦♦	STRESSES** 1/2 Sh
744	PI-233-29	32B	CC	554	L/S	0.2069	0.2350	2709	7500
* 837	PI-310-2	4A	HC	008	S	0.5480	0.6110	8379	7500
205	PI-206-44	40-II	VC	592	S	0.0680	0.0520	156	8825
508	PI-221-14	MS-24	MS	061	S	0.4420	0.3962	3849	7500
722	PI-233-24	36	CC	532	L/S	0.1985	0.1531	790	7500
554	PI-224-3	3	AF	014	S	0.2605	0.2212	1674	7500
972	PI-233-40	27B	CC	633	L/S	0.0470	0.0345	310	7500
[illegible]8	PI-206-59	39C	VC	635	S	0.0217	0.0208	293	9375
* 24	PI-205-VIII	V	SI	017	L	0.5010	0.4610	3496	7156
293	PI-211-12	4D	WG	022	S	0.3358	0.3057	2064	7000
604	PI-233-VI	CL-SFP	CL	035	L	0.1108	0.0845	289	7500
875	PI-221-23	2MS-6R	MS	102	S	0.2124	0.1565	460	7500
136	PI-206-26	10Q	VC	523	S	0.3270	0.3939	5372	8482
* 802	PI-234-22	RC-25	RC	049	S	0.5068	0.4049	1747	7215
647	PI-233-14	8	CL	111	S	0.4400	0.4150	3317	7500
853	PI-321-1	8	EG	008	L	0.1160	0.0800	85	5400
924	PI-326-8	29A	FO	029	S	0.0916	0.0810	951	7500
*1118	CC-31-011	31-011	CC	007	L	0.5050	0.6360	8441	7500
1094	KEW-206-16	15	CVC	051	S	0.4190	0.3325	1729	8963
1030	KEW-016-1	4B	RBV	004	S	0.1705	0.1440	1525	7500
[illegible]7	KEW-206-15	8(INT.)	CVC	064	S	0.6176	0.7448	10419	8688
*1100	KEW-206-14	2(INT.)	CVC	057	S	0.6126	0.5862	6483	8688
1289	KEW-MS-5	19	SW	045	S	0.0994	0.0803	658	7500

TABLE 2.2 (Continued)
SUMMARY OF EXISTING STRESS LEVELS FOR 58 SAMPLES

RECORD NO.	REPORT NO.	PART NO.	SYSTEM ID	INDEX NO.	PIPE SIZE♦	MAX STRESS RATIO UPSET	MAX STRESS RATIO FAULTED	STRESSES** OBE♦♦	STRESSES** 1/2 Sh
1195	KEW-MS-8	56	GWP	038	S	0.2685	0.1931	1004	7500
1042	KEW-205-6A	3A	SI	011	S	0.2790	0.2432	2706	9155
1291	KEW-MS-6	24	SW	048	S	0.1940	0.1795	1355	7500
1388	SW-02-002	02-002	SW	093	L	0.2199	0.2421	2901	7500
1098	KEW-206-16	19	CVC	055	S	0.1717	0.1205	818	9375
1126	KEW-210-6	VI	CC	018	S	0.2084	0.1769	1692	7500
1279	KEW-233-10	IV.BB	SW	034	L	0.2688	0.3136	3683	7500
1258	SW-02-016	02-016	SW	010	L	0.1490	0.1206	1021	7500
1[illegible]	KEW-206-7	12	CVC	018	S	0.2320	0.1985	2892	8963
1358	RHR-34-004	34-004	RHR	001	L	0.4522	0.4467	3918	7025
1287	KEW-MS-3	14(A)	SW	043	S	0.1526	0.1374	1236	7500

NOTES: * These samples are the relevant analytical parts.
**Stresses are in psi.
♦ Pipe size, S = small bore and L = large bore
♦♦Includes torsional stresses.

Any of the analytical parts having either -

a) maximum Upset or Faulted stress ratio to the allowable ≥ 0.5,

or

b) maximum OBE stress, including the effect of torsion, ≥ ½ S_h, (S_h = material allowable stress at design temperature) is considered relevant and is evaluated further.

For each of the 58 samples, the existing maximum stress ratios for Upset and Faulted conditions and the maximum OBE stress values are obtained from the Analysis of Record (AOR). Table 2.2, which is extracted from Reference 3 and included in this report, summarizes the existing maximum stress ratios and maximum OBE stress, along with the ½ S_h values for each of the 58 analytical parts.

After screening the 58 samples, there are 13 relevant samples which are chosen for further study. These relevant samples are identified in Table 2.2.

2.3 ANALYSIS OF RELEVANT SAMPLES

USAS B31.1.0-1967 Code (Reference 1) does not provide an equation to calculate the combined pipe stress due to pressure, sustained and occasional loads. The method used to calculate the combined stress including the effect of torsional moment is provided in Reference 4. The resultant moment due to deadweight and seismic loadings are calculated using the square root of the sum of squares (SRSS) of the three moments with the stress intensification factor applied, as appropriate, to the

two bending moments. This approach of including torsional moment is consistent with the calculation of expansion stress presented in the Code (Reference 1). If USAS B31.1.0-1967 Power Piping Code had required the inclusion of torsional moments, then the method used in this study would have been appropriate.

Reference 3 documents the pipe stress analysis for 13 relevant samples, for the inclusion of torsional moment. The revised Upset and Faulted stress ratios to the allowable are tabulated as shown in Table 3.1.

3.0 RESULT

All of the 13 relevant analytical parts meet the USAR criteria when the torsional moment is included in the pipe stress calculation. Table 3.1 provides the summary of Upset and Faulted stress ratios for "without torsion" and "with torsion" cases for each of the 13 relevant analytical parts. The distribution of 58 samples, in regards to the pipe size (small bore and large bore) is shown in Table 3.1 as supplementary information. Increases in combined stresses for Upset and Faulted loadings are nominal when the torsional moment is included in the stress calculation. For the worst case, which is Report No. PI-234-19, Part No. 3B, the Upset stress ratio is increased from 0.813 to 0.870 after the torsional moment is included.

TABLE 3.1

RESULTS OF SAMPLING STUDY

DISTRIBUTION OF 58 SAMPLES:

	PRAIRIE ISLAND	KEWAUNEE
ORIGINAL SAMPLES	41	17
STRICTLY LARGE BORE	7	5
SMALL-LARGE BORE	8	0
STRICTLY SMALL BORE	26	12

RELEVANT ANALYTICAL PARTS

		MAXIMUM STRESS RATIO			
		WITHOUT TORSION		WITH TORSION	
REPORT NO.	PART NO.	UPSET	FAULTED	UPSET*	FAULTED*
PI-216-3	3	0.471	0.540	0.490	0.560
PI-213-9	2CA-2	0.452	0.584	0.520	0.630
PI-234-19	3B	0.813	0.624	0.870	0.690
PI-205-IV	48	0.703	0.757	0.780	0.810
PI-216-3	1	0.556	0.675	0.740	0.800
PI-233-XV	VI	0.621	0.749	0.650	0.770
PI-216-V	9A&9B	0.660	0.731	0.720	0.790
PI-310-2	4A	0.548	0.611	0.640	0.720
PI-205-VIII	V	0.501	0.461	0.560	0.510
PI-234-22	RC-25	0.507	0.405	0.530	0.430
CC-31-011	31-011	0.505	0.636	0.530	0.670
KEW-206-15	8(INT)	0.618	0.745	0.640	0.760
KEW-206-14	2(INT)	0.613	0.586	0.660	0.650

* NOTE: The stress ratios are conservatively calculated according to Reference 4.

4.0 CONCLUSION

All of the 58 sample analytical parts satisfy the USAR criteria when the torsional moment is included in the combined pipe stress calculation for Upset and Faulted conditions. From this study, it is concluded that the torsional moment does not contribute significantly to the pipe stresses.

5.0 REFERENCES

(1) USAS B31.1.0-1967, Nuclear Power Piping Code.

(2) USAR for Prairie Island Nuclear Generating Plant, Revision dated February 20, 1986.

(3) "Evaluation of pipe stress, including the effect of torsional moment for 58 sample analytical parts," Calculation No. M.834486.02, Dated 2-24-89, Project No. 834486.

(4) "Procedure to perform sampling study to evaluate the effect of torsional moment on pipe stress qualification," Procedure No. 834486-1, Project No. 834486, Dated February 3, 1989.

(5) "Random selection of samples from the total population of analytical parts contained in Prairie Island and Kewaunee Projects," Calculation No. M.834486.01, Project No. 834486, Dated February 10, 1989.

(6) "Documentation of Methodology used for combination of moments for piping constructed to the USAS B31.1-1967 Power Piping Code," prepared by R.F. Petrokas and E.O. Swain, Dated February, 1989.

(7) USAR for Kewaunee Nuclear Power Plant, Revision dated July 1, 1986.